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(54) Title: HIGHLY COMPRESSED FILTE TOW BALE AND METHOD FOR THE PRODUCTION THEREOF

(57) Abstract: Disclosed is a packed, highly compressed cuboid-shaped filter tow bale, the top side and bottom side of which are free from nuisance curvatures or constrictions. Said bale is characterized by the fact that a) the bale has a packing density of at least 300 kg/m<sup>3</sup>, b) the bale is entirely wrapped in a mechanically self-supporting, elastic packing material which is provided with one or several convectively airtight connections, and c) the top side and bottom side of the bale are so flat that a flat plate which fully covers the bale can be pressed onto the top side of the bale via a centrally effective normal force of 100 N and at least 90 percent of the surface of the top side of the bale, which lies within the largest rectangle that can be inserted by vertically projecting the bale onto the pressed plate, has a maximum distance of about 40 mm from the flat plate when the unopened bale is placed on a horizontal plane. A particularly suitable method for producing said bale comprises the following steps: a) filter tow is supplied in a compressed form; b) the compressed filter tow is enveloped in a wrapping; c) the wrapping is closed in an airtight manner; and d) the wrapped bale is relieved of the load. The wrapping of such a bale is largely prevented from bursting as a result of the prevailing internal pressure. The inventive bale has an ideal cuboid shape such that curvatures negatively affecting the bale during transport or constrictions hampering the behavior of the filter tow are largely prevented from occurring.



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*For two-letter codes and other abbreviations refer to the  
"Guidance Notes on Codes and Abbreviations" appearing at  
the beginning of each regular issue of the PCT Gazette.*

### Highly-Compressed Filter Tow Bale and Method for the Production Thereof

The invention relates to a packed, highly compressed, cuboid filter tow bale without interfering curvatures or constrictions on the top and bottom of the bale, as well as a method for the production thereof.

During the production of filter tow for filter tips for the cigarette industry, the tow is placed in so-called "filling cans". The filter tow is distributed uniformly as a layer over the cross-sectional surface of the filling can as a result of the changing movement in the longitudinal and transverse direction of a depositing unit. As many layers are deposited one on the other until the filter tow package has reached the desired weight and height in the filling can. Packing weights of several hundred kilograms are common in this field. A highly compressed bale and a method for the optimal filling of the filling can and therefore avoidance of the resulting processing problems are described in WO 02/32238 A2.

The content of the cans so filled is then compressed in the direction of the superimposed layers. After compressing is completed, the filter tow packing, which is still under a compressive stress, is wrapped with a packing material still within the compression device and the compression device is then fully opened so that the packing material holds together the filter tow packing as a so-called bale. Cardboard held together mechanically by taping or gluing, or synthetic fabric that is closed, for example, by a velcro closure are common packing materials. An example of a glue package is described in German Utility Model 7635849.1. Information on a filter tow packing with synthetic fabrics can be found in the company brochure "Some Useful Information about the Reusable Packaging for Rhodia Filter Tow": Rhodia Acetow GmbH, Engesserstrasse 8, D-79108 Freiburg. The two last-named types of packing get by without additional taping.

In the case of the package types without additional taping, the packing material is exposed to a pressure owing to the elastic restoring force of the compressed filter tow after the load is relieved on the bale at the end of the compression step, especially against the direction of compression, which leads to an increase in packing volume and to undesired curvatures on the top and bottom of the bale. These curvatures do not interfere with the intended use of the filter tow, when the steps described in WO 02/32238 A2 are maintained, but do prevent reliable stacking of the filter tow packages. This problem is solved according to the prior art either by lateral stacking of the

bales or as a result of the use of special pallets, as described in the aforementioned Rhodia document. Problems also frequently occur in conjunction with the bursting of packages because of an unduly high internal pressure.

One solution for the difficulties with taping is described in US-A-4,577,752. In the case of the taped package variations, the curvatures during the intended use are less of a problem than those described in WO 02/32238 A2 as a result of the differences in drag resistance occurring in the constriction. However, bursting of such taped bales can also occur. The use of an in-liner between the filter tow and the aforementioned mechanically supporting packing materials is also common in packing of filter tow. The in-liner then protects the filter tow from contamination especially of the odorous type and from diffusion of water vapor into the package or from it. The in-liner generally consists of three pieces inserted loosely in the outer package.

The object of the invention is to provide a highly compressed filter tow bale in ideal cuboid shape without curvatures that interfere with transport of the bale, or constrictions on the top and bottom of the bale that hamper discharge of the filter tow, in which the pressure stress on the packed filter tow is reduced and bursting of packages under internal pressure can largely be avoided. Another object of the invention is to offer a corresponding packing method.

These tasks are solved in accordance with the invention by means of a cuboid filter tow bale according to Claim 1 and a method according to Claim 14.

The object of the invention therefore is a packed, highly compressed, cuboid filter tow bale without interfering curvatures or constrictions on the top and bottom of the bale, characterized by the fact that a) the bale has a packing density of at least  $300 \text{ kg/m}^3$ , b) the bale is fully enclosed with a mechanically self-supporting, elastic packing material, with this material having one or more convectively air-tight connections, and c) the top and bottom of the bale are flat so that, when the unopened bale is arranged on a horizontal plane, a flat plate fully covering the bale can be pressed onto the top of the bale with a centrally acting normal force of 100 N, and, within the largest rectangle that can be inscribed by means of the vertical projection of the bale onto the pressed plate, at least 90% of the top surface of the bale that lies within the inscribed rectangle has a maximum distance of 40 mm to the flat plate.

The drawbacks of the now common transport packages have already been mentioned in description of the prior art. In this case it is mostly the curvatures of the bale on the bottom and top of the bale that interfere with double-layered transport. This problem is solved by means of transporting the bales not in the so-called operative position, but in a lateral storage position.

Two additional working steps are required for this, namely rotation of the bale by 90° before transport and back-rotation of the bale into the operative position after transport. The constrictions formed by taping also constitute a drawback. These become noticeable during the intended use of the bale in the form of the higher scatter of the drag resistance of the filter tips produced from the filter tow. More than 5% of the filter tips produced from a bale are affected by this phenomenon. Both problems are more severe, the higher the packing density of the bale. These problems occur starting from a packing density of more than 300 kg/m<sup>3</sup>.

After a series of futile attempts, it was surprisingly found that a cuboid bale without curvatures that interfere with transport and without constrictions that interfere with the intended use can be prepared, if the package was closed air-tight during the packing process. For practical consideration the bale according to Claim 1 is therefore fully enclosed with a mechanically self-supporting elastic packing material, this material having one or more convectively air-tight connections.

One might imagine on a first superficial analysis that the bale according to the invention is a vacuum-packed bale, i.e., that the type of vacuum packing is involved that is quite well known to any consumer from daily use. However, this is not the case. The objective in the case of the cuboid bale according to the invention is to produce a defined shape. The air-tight packing during the production process has the objective of absorbing and equalizing pressure gradients on the top and bottom of the bale. Requirements on the packing, like strength of the packing, air and moisture permeability, etc., could be dispensed with. On the contrary, the bale according to the invention would retain its properties even if the previously air-tight material were to be perforated over a large area after the packing process. Such an additional measure is dispensed with for practical reasons<sup>TN</sup>.

The geometry of the bale according to the invention is described by characteristic c) in Claim 1. The spacing of the individual points of the top of the bale can be determined, for example, by means of using a transparent plate as the plate and determining the spacing of the individual points from the plate by means of a reflection measurement. Any other continuous method of spacing measurement can be used as an alternative. In the context of the teachings according to the invention, it is particularly preferred if 90% of the surface of the top of the bale that lies within the mentioned inscribed rectangle has a maximum spacing of about 25 mm, especially a maximum of about 10 mm to the flat plate.

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<sup>TN</sup> **Translator's Note:** it seems somewhat unclear what the reference to the "additional measure" actually relates to, but this ambiguity is the same in the German source text.

As regards the packing volume of the bale, it has been shown to be advantageous if the bale has a volume of more than  $0.9 \text{ m}^3$  and/or the packing density is more than  $350 \text{ kg/m}^3$  and especially less than  $800 \text{ kg/m}^3$ . In conjunction with loading of the packages into containers, a cuboid shape with a height of at least about 900, especially at least about 970 mm, has proven to be particularly suitable for the bale. In this case the bales can be placed in the container in double stacks. Heights of the packed cuboid from 970 to 1200 mm are particularly favorable, these cuboids being placed into the container in the form of individual stacks. It is also possible to produce much higher bales so that the packing expense is minimized relative to the amount of fiber being packed. In the case of packing of filter tow, such large packages have the advantage that a change of the bale need only occur occasionally during use of the filter tow to produce cigarette filters in a filter tip machine.

The wrapping is preferably a plastic foil. In this case the convectively air-tight connection is designed as a convectively air-impermeable seam with particular advantage as an overlapping sealing or fin seam.

The foil preferably consists of polyethylene, especially LDPE, or modified polyethylene (LLDPE) or a composite film with a polyamide and a polyethylene layer. For advertising and/or aesthetic purposes, a colored or printed foil can be used as the packing foil. This is particularly useful when the filter tow being packed is light-sensitive. The foil can also be provided with stickers having information with reference to the content of the package. Another possibility of conveying information with the packing is embossing of a relief that is visible through the tightly attached film because of the vacuum. In addition to product name, the relief can also contain a company and/or customer logo. The foil preferably has properties that make it a reliable transport package. This explains why foils with a thickness of 100 to  $400 \text{ }\mu\text{m}$  are used in particular. If desired, a transport packing made of cardboard, synthetic fabric, etc. can be added around the foil in conjunction with a final sealing of the wrapping or foil, i.e., after preparation of the cuboid bale. This can additionally be taped. The mechanical stability of the package is increased by this measure so that thinner and therefore less expensive foils can be chosen. However, it must be emphasized that this type of transport package is not absolutely essential in the context of the invention.

The method for the packing of a filter tow bale according to the invention has the following process steps: a) preparation of the filter tow in compressed form, b) wrapping of the compressed filter tow with a wrapping, c) air-tight sealing of the wrapping and d) relief of the load on the wrapped bale. When the load is relieved on the air-tight sealed bale, a vacuum develops within

the wrapping which is preferably at least 0.01 bar and according to a particularly advantageous method 0.15 to 0.7 bar.

Because of air-tight sealing of the wrapping, the produced vacuum can be maintained within the area enclosed by the wrapping. This vacuum reduces the pressure exerted on the packing by the flexible material because of the elastic restoring force from the interior. For this reason, curvatures of the packaged filter tow bale, which are common according to the prior art, are avoided. The stackability of the produced packages is increased as a result of this. Owing to the mechanical pressure, which is reduced by the vacuum, from the inside on the packing, the risk of failure or tearing of the packing is also reduced. In this way a higher packing density can be achieved, which leads to the advantage of compact packages and therefore reduced storage and transport volumes. In particular, the volume capacity of containers in which such packed filter tows are to be stored can be optimally utilized in this way.

Preparation of the filter tow in compressed form generally occurs by means of the known compression equipment. The method according to the invention can be carried out, in the first place, so that the amount of filter tow prescribed for packing is first mechanically compressed in the compression device and then enclosed with the wrapping. Sealing of the wrapping occurs in this case within the compression device. This embodiment has the advantage that the entire process is conducted in one location.

In the second place, it is also possible to conduct compression of the filter tow beforehand in a separate station. In this case, the already compressed filter tow is fed to "auxiliary packing", which can consist of holding clamps, where the auxiliary packing is removed and wrapping of the compressed filter tow with the wrapping and generation of the vacuum and air-tight closure of the wrapping are conducted. This embodiment has the advantage that, since the entire process is conducted at the location of the compression device, this has higher availability. In addition, the compression cycle is shorter in duration and there are more degrees of freedom during application of the wrapping, since the compressed bale is accessible from all sides in the packing station.

Unlike the prior art, when the method according to the invention is used, in-liners to protect from soiling and water vapor can be dispensed with, since these objective are already met by the wrapping used for packing.

The vacuum initially required in the method according to the invention can be obtained in different ways. According to a particularly simple embodiment, the vacuum is produced by

means of the expansion of the compressed filter tow material. After the filter tow has been wrapped in the compressed state with the wrapping and this then closed air-tight, the external pressure on the packed material is reduced so that it expands under the influence of the elastic restoring force within the packing. Because of the increase in the package volume, a partial vacuum is formed within the region enclosed by the wrapping. The packing size is preferably chosen so that expansion of the compressed filter tow is not complete, i.e., the filter tow is still in the compressed state within the packing within the wrapping even after partial expansion. This embodiment has the advantage that no additional means are required to produce the partial vacuum. This therefore represents a particularly cost-effective possibility.

According to another embodiment that can be used as an alternative or in addition to the embodiment just described, the partial vacuum is produced by air suction within the region enclosed by the wrapping. In this way a higher vacuum can be achieved than the "intrinsic vacuum" that was just described. It is also possible to adjust the desired partial vacuum with high accuracy in this way.

Suction can be carried out, for example, by means of one or more vacuum pumps. These are initially connected on the intake side with the interior of the otherwise air-tight closed package, whereupon they are started. After the desired partial vacuum is reached, the pumps are separated again from the package and the suction connection sites of the wrapping are closed air-tight again.

A combination of the two embodiments just mentioned has the advantage that the evacuation times can be kept short, since the partial vacuum is obtained by two different measures, which can be conducted simultaneously. In addition, the required compression forces are lower, since a higher packing dimension can be chosen, "packing dimension" being understood to mean the height of the filter tow bale during air-tight closure in the compression device used for compression. Finally, the height of the filter tow bale can be regulated with good accuracy in this way. Other influences in the filter tow, especially seasonal, titer, weight influences, etc. can be compensated by this.

A partial vacuum of about 0.15 bar to 0.7 bar below the ambient pressure is preferably produced in the method according to the invention. This corresponds to an absolute pressure of about 0.85 to 0.3 bar within the region enclosed by the foil. A partial vacuum in the low vacuum range is therefore involved, which is generally fully sufficient for the method according to the invention. A partial vacuum of about 0.2 to 0.4 bar, corresponding to an absolute pressure of about 0.8 to 0.6 bar has proven to be particularly suitable. The choice of the specific range for the partial



vacuum depends on different parameters, especially the type and amount of material being packed, the desired packing density, the employed wrapping etc. In principle, it must be kept in mind that more compact packages could be achieved, the higher the vacuum or partial vacuum. Curvatures can also be reduced more strongly with increasing partial vacuum. However, it must be kept in mind that the times to achieve the partial vacuum increase disproportionately, the higher the desired vacuum.

As regards the wrapping used in the method according to the invention, this should be chosen so that the desired time stability of the produced partial vacuum, as well as the desired mechanical stability of the package is guaranteed. Depending on the packed product and the type of application, the desired time stability will generally vary between a few days and several months or even years. Foils with different air permeabilities can therefore be used accordingly.

According to one embodiment a foil of polyethylene or modified polyethylene, for example LLDPE or LDPE, is used as wrapping. LDPE is understood to mean low-density polyethylene produced under high pressure, the term LLDPE is the abbreviation for linear low-density polyethylene. This type of foil has the advantage that it is a pure-grade foil that is also available at low cost. However, a polyethylene foil has comparatively limited strength so that it is suitable in particular for smaller packing densities and small amounts being packed. Because of the relatively high air permeability of a standard polyethylene foil, it is more suited for use in which the storage time does not exceed a few weeks.

A composite foil with polyamide and polyethylene could be used as an alternative wrapping. This is characterized by particularly low air permeability and high strength so that the vacuum can be kept essentially constant over a long period. The amount of polyamide is about 1/3 and the amount of polyethylene about 2/3.

A gas permeability of the wrapping or foil for air of less than  $10,000 \text{ cm}^3/(\text{m}^2 \cdot \text{d} \cdot \text{bar})$ , especially less than  $200 \text{ cm}^3/(\text{m}^2 \cdot \text{d} \cdot \text{bar})$  and with particular preference less than  $20 \text{ cm}^3/(\text{m}^2 \cdot \text{d} \cdot \text{bar})$  is preferred. These values are measured according to DIN 53380-V at  $23^\circ\text{C}$  and 75% relative humidity. This guarantees that the vacuum is retained sufficiently long and the package does not become loose and remains as compact as possible. The range is also covered by commercially available foils (for example PA-PE composites). It must be emphasized that no convective air transport occurs through the foil, but mass transport occurs only via diffusion through the foil. The mentioned values for permeability refer to surrounding air of analogous composition (about 78%  $\text{N}_2$ , 21%  $\text{O}_2$ , 1% other gases). In this case only the permeability relative to oxygen and

nitrogen matters. In addition to foils, other air-tight materials that meet the aforementioned conditions can also be used in the context of the present invention.

The water vapor permeability of the foil or other wrapping material should preferably lie below  $5 \text{ g}/(\text{m}^2 \cdot \text{d})$  and especially below  $2 \text{ g}/(\text{m}^2 \cdot \text{d})$  measured according to DIN 53122 part 2 at  $23^\circ\text{C}$  and 85% relative humidity. Water vapor permeability is not relevant for the shaping function of the package. However, a package that is not only air-tight, but also water vapor-impermeable has the advantage that the product moisture of the filter tow is retained by such a package. This is of considerable importance in filter tow. The moisture content is equalized over the bale and no exchange of water vapor with the surroundings occurs. Polyethylene foil that is  $100 \mu\text{m}$  thick has a water vapor permeability of about  $1 \text{ g}/(\text{m}^2 \cdot \text{d})$ .

As regards mechanical strength, the wrapping or foil should expediently have a tensile strength of at least about  $10 \text{ N}/15 \text{ mm}$ , preferably more than  $100 \text{ N}/15 \text{ mm}$  and especially more than  $200 \text{ N}/15 \text{ mm}$ , measured according to DIN EN ISO 527-3. The mentioned values refer to the minimum of tear strength in the longitudinal and transverse direction of the foil. The specific choice with reference to tear strength is made depending on whether the foil-packed bale is still repacked for transport. PE with a tensile strength of  $15$  to  $30 \text{ N}/15 \text{ mm}$  at  $100 \mu\text{m}$  thickness, as well as PA6 with a tensile strength of  $150$  to  $300 \text{ N}/15 \text{ mm}$  at a thickness of  $100 \mu\text{m}$  can be mentioned in this context.

In general, plastic foils with air barrier layers, for example made from polyamide, polyester or ethylene-vinyl alcohol copolymer (EVOH) or with a metal coating, for example  $\text{SiO}_x$ , aluminum oxide, etc., as well as aluminum foil have proven to be particularly advantageous as plastic foils with air barrier layers. The listed foil types are considered to be non-restrictive. Owing to the air impermeability of the foil, aroma protection, i.e., protection against aromas penetrating from the outside is also guaranteed, which can be advantageous in differently packed products. A certain toughness of the foil is important for its mechanical stability. This is achieved particularly well by polyamide.

One possibility for an air-tight sealing of the wrapping or foil consists of welding or sealing it. The selected foil should preferably be weldable or sealable accordingly. In this context low melting materials are favorable for the foil. For example, polyolefins, for example polyethylene or polypropylene, or copolymers with ethylene or propylene, for example EVA, LLDPE, etc. can be mentioned in this context. Materials that meet the requirement of weldability or sealability are referred to below as a sealing layer. A foil can optionally consist of such a sealing layer

alone or also of a composite of one or more sealing layers and additional layers that guarantee, for example, mechanical strength.

In order to guarantee a simple opening of the package, the sealing layers can be peelable, i.e., not homogeneously sealable. Such a nonhomogeneous sealing layer can be produced in different ways, for example by admixing of polybutylene at certain sites in the sealing layer or by sealing of polypropylene against LLDPE. Another possibility of producing an opening aid consists of providing a tear-off strip in the package foil. This possibility works particularly well in foils with limited toughness. Finally, protruding corners or the like can be provided that are intended to be cut off during opening of the package. After cutting off the protruding corner, air can penetrate into the interior of the package so that the package loosens. This can then be opened without problem with a foil blade without damaging the package content.

As an alternative, sealing of the wrapping or foil can occur by gluing. This embodiment has the advantage that a sealing device can be dispensed with. Other appropriate types of sealing of the package foil can naturally be used as long as they fulfill the desired properties with reference to tightness and also mechanical tensile strength that are required for the corresponding application.

Sealing or welding can occur, for example, with formation of an overlapping seam. An overlapping seam can take up comparatively high tensile forces and thus hold the packed material together, especially in the freshly packaged state, even if the package is not tight and the full elastic restoring force acts on the package from the inside. Therefore, this type of sealing is particularly reliable, in which case the foil should expediently have a sealing layer on both sides (or by itself must consist of such a sealing layer).

According to another embodiment, welding or sealing can occur by means of the formation of a fin seam, known to one skilled in the art of foil processing. This has the advantage of being easy to produce from the outside, but in which case its capability to withstand tensile loads is lower than that of an overlapping seam.

The wrapping or foil can be designed for example in the form of a one-piece sack. The wrapping of the prepared filter tow in this case occurs in similar fashion to the packing of candy. As an alternative, the film can consist of a bottom, a cover and an enclosing sleeve. In this case the total length of the joining seams is increased, since the individual parts must be joined.

According to another preferred embodiment, the foil packaging consists of a cover and a bottom that are optionally prefabricated, for example deep drawn or made into a bag or the like. Finally there is also the possibility of designing the foil like a tennis ball from two intermeshing

pieces. In addition, other appropriate types of formation of a foil package are conceivable within the context of the invention.

If desired, a wrapping of cardboard, synthetic fabric, etc. can be added around the foil in connection with final sealing of the wrapping or foil, i.e., after production of the foil packing. The mechanical stability of the package can be increased as a result of this so that thinner and therefore more cost-effective foils can be chosen. However, it must be emphasized that such a wrapping is not absolutely essential in the context of the invention.

During use of a wrapping as just mentioned, there is possibility that the foil packing is deliberately designed with low impermeability so that the partial vacuum is equalized within one to two days relative to the surrounding pressure. In other words, the package "loses" its vacuum within this period. The packed filter tow therefore expands into the wrapping, but in which case it has a lower curvature on the top and bottom of the package in comparison with a filter tow packed according to a method of the prior art.

The foil used in the method according to the invention preferably has a thickness of about 100 to 400  $\mu\text{m}$ , a range from 200 to 300  $\mu\text{m}$  and especially from 250 to 300  $\mu\text{m}$  having proven to be particularly suitable. The precise thickness of the employed foil is chosen as a function of the size and weight of the fiber material being packed, the degree of compression, i.e., the packing density, and the type of employed foil material. As already mentioned above, the foil can optionally be chosen to be somewhat thinner, if an additional wrapping, for example, made of cardboard, is used.

The compressible filter tow being packaged is furnished especially in an optimal cuboid shape. Because of this, packages can be achieved that can be stacked and handled particularly well and are easy to store. In filter tow present in the form of tows, the tows are preferably layered one on the other in individual layers, as already outlined in conjunction with the method according to the prior art.

The invention is explained in detail below by means of a preferred embodiment with reference to the enclosed drawing. In the drawing:

Figure 1a to 1c shows individual steps of an embodiment of the method according to the invention;

Figure 2a and 2b shows an expansion of the packing produced according to the method of the invention;

Figure 3a shows a graph depicting the properties of a packing produced according to the method of the invention using a polyethylene foil as a function of time;

Figure 3b shows a graph similar to that of Figure 3a, but for a composite polyethylene and polyamide foil;

Figure 4a shows different curves that depict the relation between packing dimension and bale height for different vacuums;

Figure 4b shows different curves that depict the relation between additional vacuum and bale height at increased temperature and lower air pressure.

A bale of a compressed flexible fibrous material 1, in the present case filter tow, is wrapped with a foil 2 and introduced to a compression device 3, as is apparent in Figure 1a. The bale is compressed to the desired packing dimension in the compression device 3, which, for example, has a compression force from 300 to 400 t. The foil 2 is then closed air-tight, except for a small region that serves as a connection site for the suction line of a vacuum pump 4, for example a vane-type rotary pump or the like. The interior of the region enclosed by foil 2 is then evacuated to a desired partial vacuum by means of vacuum pump 4. When this is reached, the tube of the vacuum pump is separated from the foil and the connection site closed air-tight. As already mentioned, the use of a vacuum pump can be dispensed with, if only a low partial vacuum is desired, which is obtainable by expansion of the bale.

In the next step, which is shown in Figure 1b, compression device 3 is opened, during which the bale partially expands again, if the size of the foil packing permits. The finished packed filter tow bale can now be removed from the compression device and is in a condition suitable for transport and storage, as shown in Figure 1c. The height of the packaged bale depends, among other things, on the level of the produced vacuum.

Another step in the method according to the invention is apparent in Figures 2a and 2b, mainly optionally providing the packed filter tow bale with a wrapping 5. This can be provided in particular for transport and can consist of light cardboard. Such wrappings are known to one skilled in the art and therefore are not further explained in this case.

Figure 3a and 3b each show a graph representing the properties as a function of time of a packing produced according to the method of the invention, using a polyethylene foil or composite polyethylene and polyamide foil. The polyethylene foil of Figure 3a has a gas permeability of about  $600 \text{ mL}/(\text{m}^2 \cdot \text{d} \cdot \text{bar})$ , whereas the gas permeability of the composite foil of Figure 3b is only about  $10 \text{ mL}/(\text{m}^2 \cdot \text{d} \cdot \text{bar})$ . As follows from a comparison of the two graphs, the generated partial vacuum in the case of the composite foil remains essentially constant over several hundred days,

as does the bale height. On the other hand, the partial vacuum in the case of the polyethylene foil after somewhat more than 100 days has already diminished by half, while the bale height increased by more than 10 cm in the same period. When the intended storage times are high up to 2 years and more, a composite foil is therefore provided, despite the higher costs.

As is shown in Figure 4a, the bale height can be kept smaller, the higher the employed vacuum. Three different graphs are shown in the figure, the uppermost one showing the attainable bale height as a function of package dimension of the bale without using a vacuum pump, the middle graph during use of an additional vacuum of 0.1 bar and the lower graph during use of additional vacuum of 0.1 bar. A filter tow type 3Y35 with a bale weight of 580 kg was processed at a pressure of 370 t. An additional vacuum of 0.1 bar under these conditions can be reliably produced in about 60 seconds.

The bale height with altered environmental conditions is shown as a function of level of the additional vacuum in Figure 4b, in which the air temperature was about 40°C and the atmospheric pressure of the surroundings about 0.05 bar higher than in the example of Figure 4a. It is apparent that the bale height increases at lower air pressure and increased temperatures.

A composite foil of polyethylene and polyamide with a thickness of about 200 µm was used in the described practical example. The foil was sealed by hand with a sealing device, during which a smooth part was joined to a prehinged cover and bottom element in the press. The compression force was always 370 t. The packing costs were significantly reduced with the help of the method according to the invention.

According to another experiment, a bale of the same weight in a packing height of 900 mm was enclosed with a composite foil of polyamide and polyethylene and this then sealed. After opening of the compression device, the height was 970 mm. No bale bulging in the package occurred. A partial vacuum of 0.12 bar corresponding to an absolute pressure of 0.88 bar was produced by the increase in volume of the air situated in the bale. This partial vacuum was achieved without the aid of a vacuum pump.

In another experiment, a bale of the same weight in a packing height of 900 mm was enclosed in a composite foil of polyamide and polyethylene and this then sealed, during which the interior of the package was evacuated with a vacuum pump to a partial vacuum of 550 bar, corresponding to an absolute pressure of 450 bar. After opening of the compression device the bale assumed a height of about 930 mm. A pressure in the package interior of 0.42 bar, corresponding to a partial vacuum of 0.58 bar is calculated. No bale bulging in the package occurred.

### Claims

1. A packed, highly compressed filter tow bale in cuboid shape without interfering curvatures or constrictions on the top and bottom of the bale, characterized by the fact that
  - a. the bale has a packing density of at least  $300 \text{ kg/m}^3$ ,
  - b. the bale is fully enclosed with a mechanically self-supporting, elastic packing material, this material having one or more convectively air-tight connections and
  - c. the top and bottom of the bale are flat so that, when the unopened bale is arranged on a horizontal plane, a flat plate fully covering the bale can be forced onto the top of the bale by a centrally acting normal force of 100 N, and, within the largest rectangle that can be inscribed by perpendicular projection of the bale onto the pressed-on plate, at least 90% of the surface of the top of the bale that lies within the inscribed rectangle has a maximum distance of about 40 mm to the flat plate.
2. The bale according to Claim 1, characterized by the fact that the bale has a packing volume of more than  $0.9 \text{ m}^3$  and/or the packing density is more than  $350 \text{ kg/m}^3$  and especially less than  $800 \text{ kg/m}^3$ .
3. The bale according to Claim 1 or 2, characterized by the fact that it has a height of at least 900 mm, especially at least about 970 mm.
4. The bale according to Claim 3, characterized by the fact that it has a height of about 970 to 1200 mm.
5. The bale according to one of the Claims 1 to 4, characterized by the fact that the wrapping is a foil, especially a plastic foil.
6. The bale according to at least one of the preceding claims, characterized by the fact that the convectively air-tight connection is a convectively air-impermeable seam.
7. The bale according to Claim 6, characterized by the fact that the air-impermeable seam is an overlapping sealing seam or fin seam.
8. The bale according to at least one of the preceding claims, characterized by the fact that 90% of the surface of the top of the bale that lies within the inscribed rectangle has a maximum distance of about 25 mm, especially about 10 mm, to the flat plate.

9. The bale according to at least one of the preceding Claims 5 to 8, characterized by the fact that the foil consists of polyethylene, especially LDPE or modified polyethylene (LLDPE).
10. The bale according to at least one of the Claims 5 to 8, characterized by the fact that the wrapping is a composite foil with a polyamide and a polyethylene layer.
11. The bale according to at least one of the preceding claims, characterized by the fact that the wrapping has a thickness of about 100 to 400  $\mu\text{m}$ .
12. The bale according to at least one of the preceding claims, characterized by the fact that it has an additional transport packing made of cardboard or synthetic fabric.
13. The bale according to at least one of the preceding claims, characterized by the fact that it is additionally wrapped with tape.
14. A method for packing of a filter tow bale, especially according to at least one of the preceding claims, having the following process steps:
  - a. preparation of the filter tow in compressed form,
  - b. wrapping of the compressed filter tow with a wrapping,
  - c. air-tight closure of the wrapping and
  - d. removal of the load on the wrapped bale.
15. The method according to Claim 14, characterized by the generation of a partial vacuum within the wrapping of at least about 0.01 bar relative to the outside pressure within the unloaded wrapping.
16. The method according to Claim 15, characterized by the fact that the partial vacuum is generated by intrinsic expansion of the compressed filter tow.
17. The method according to Claim 15 or 16, characterized by the fact that the partial vacuum is generated by air suction.
18. The method according to Claim 17, characterized by the fact that suction is carried out with a vacuum pump.
19. The method according to at least one of the Claims 15 to 18, characterized by the fact that a partial vacuum of about 0.15 to 0.7 bar below the surrounding pressure is generated.



20. The method according to Claim 19, characterized by the fact that a partial vacuum of about 0.2 to 0.40 bar below the surrounding pressure is generated.
21. The method according to at least one of the Claims 14 to 20, characterized by the fact that the wrapping is sealed by welding or sealing, especially to form an overlapping seam or to form a fin seam.
22. The method according to at least one of the Claims 14 to 21, characterized by the fact that a foil with a water vapor permeability of less than  $5 \text{ g}/(\text{m}^2 \cdot \text{d})$ , especially less than  $2 \text{ g}/(\text{m}^2 \cdot \text{d})$  measured according to DIN 53122 at  $23^\circ\text{C}$  and 85% relative humidity is used as the wrapping.
23. The method according to at least one of the Claims 14 to 22, characterized by the fact that a foil with a gas permeability of at most  $10,000 \text{ cm}^3/(\text{m}^2 \cdot \text{d} \cdot \text{bar})$  measured according to DIN 53380-V at  $23^\circ\text{C}$  and 75% relative humidity for air is used as the wrapping.
24. The method according to Claim 23, characterized by the fact that a foil with a gas permeability of at most about  $200 \text{ cm}^3/(\text{m}^2 \cdot \text{d} \cdot \text{bar})$ , especially at most  $20 \text{ cm}^3/(\text{m}^2 \cdot \text{d} \cdot \text{bar})$  is used as the wrapping.
25. The method according to at least one of the Claims 14 to 24, characterized by the fact that a foil with a tensile strength of at least about 10 N/15 mm, especially at least about 100 N/15 mm measured according to DIN EN ISO 527-3 is used as the wrapping.
26. The method according to Claim 25, characterized by the fact that the tensile strength is at least 200 N/15 mm measured according to DIN EN ISO 527-3.
27. The method according to at least one of the Claims 14 to 26, characterized by the fact that the method is controlled so that a packing density of at least about  $300 \text{ kg}/\text{m}^3$  is set.

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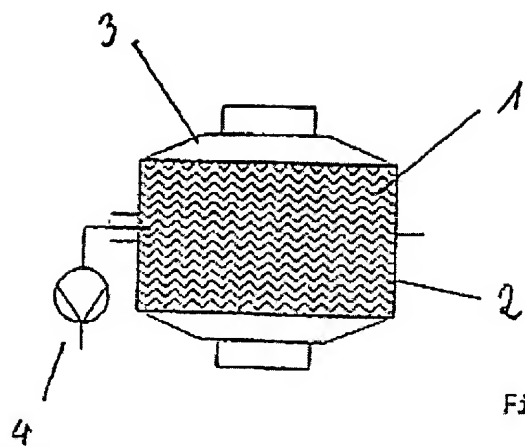


Fig. 1a

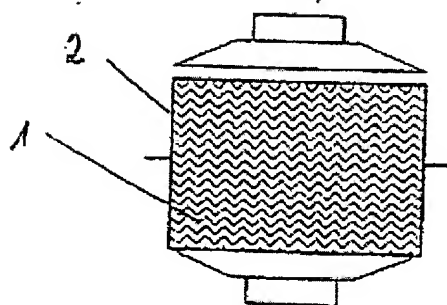


Fig. 1b

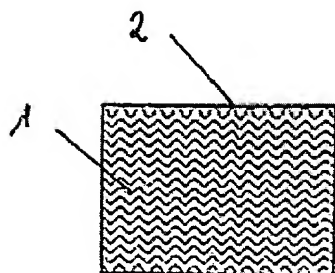


Fig. 1c

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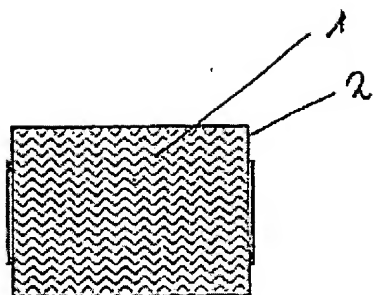


Fig. 2a

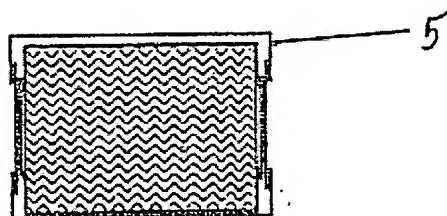


Fig. 2b

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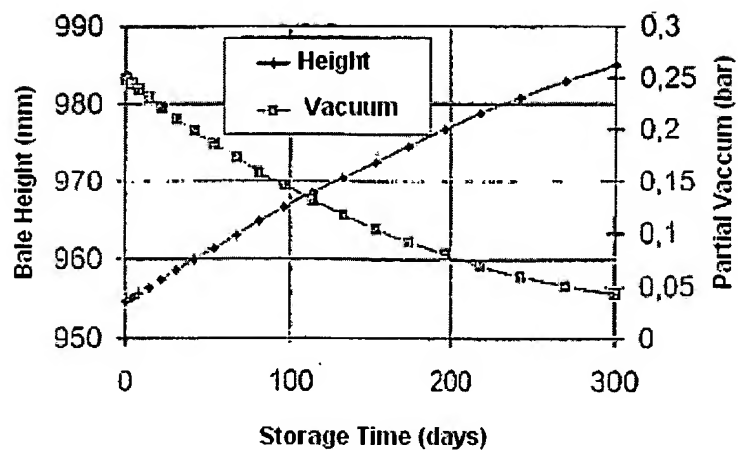


Fig. 3a

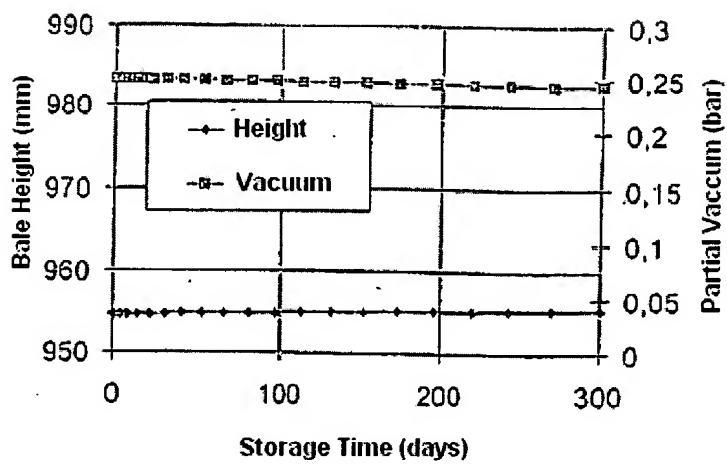


Fig. 3b

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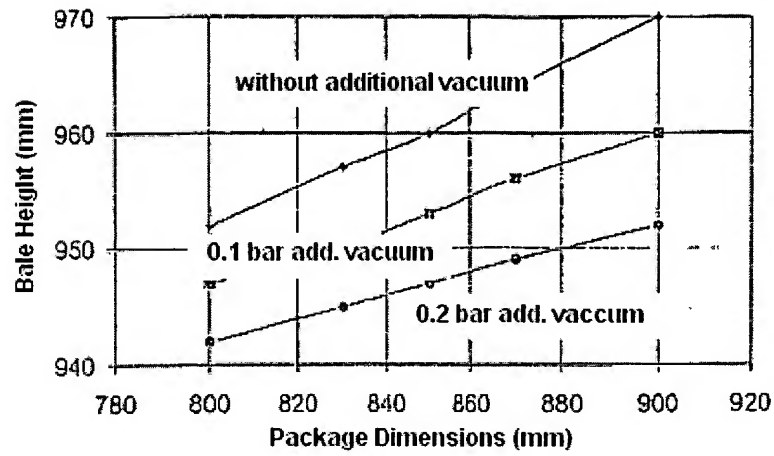


Fig. 4a

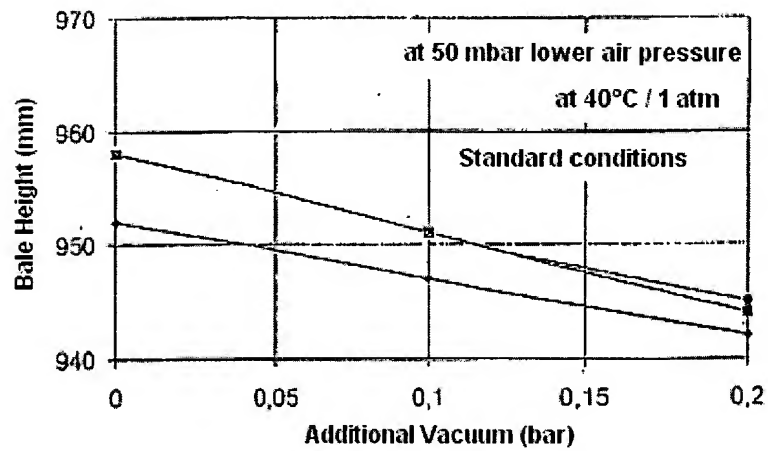


Fig 4 b